

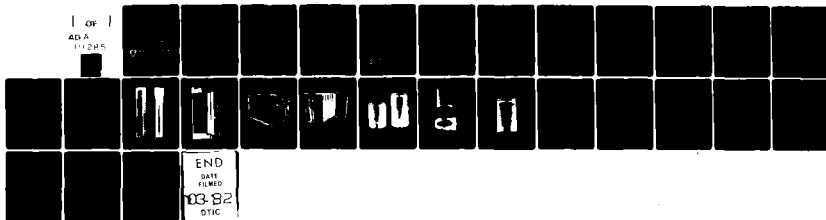
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TECHNICAL REPORT ARLCD-TR-81036

IMPROVED PACKING AND PALLETIZATION FOR 105-mm TP-T CARTRIDGE M490

THOMAS F. FITZGERALD
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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

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<p>Work was performed to design an improved method of packing 105-mm TP-T cartridge M490. The present method of pack (two fiber containers per wood box, 12 or 15 wood boxes per skid base) was replaced by an improved method (39 improved fiber containers per pallet-type wirebound box). This change improved logistics and reduced material and transportation costs for training cartridges.</p>		

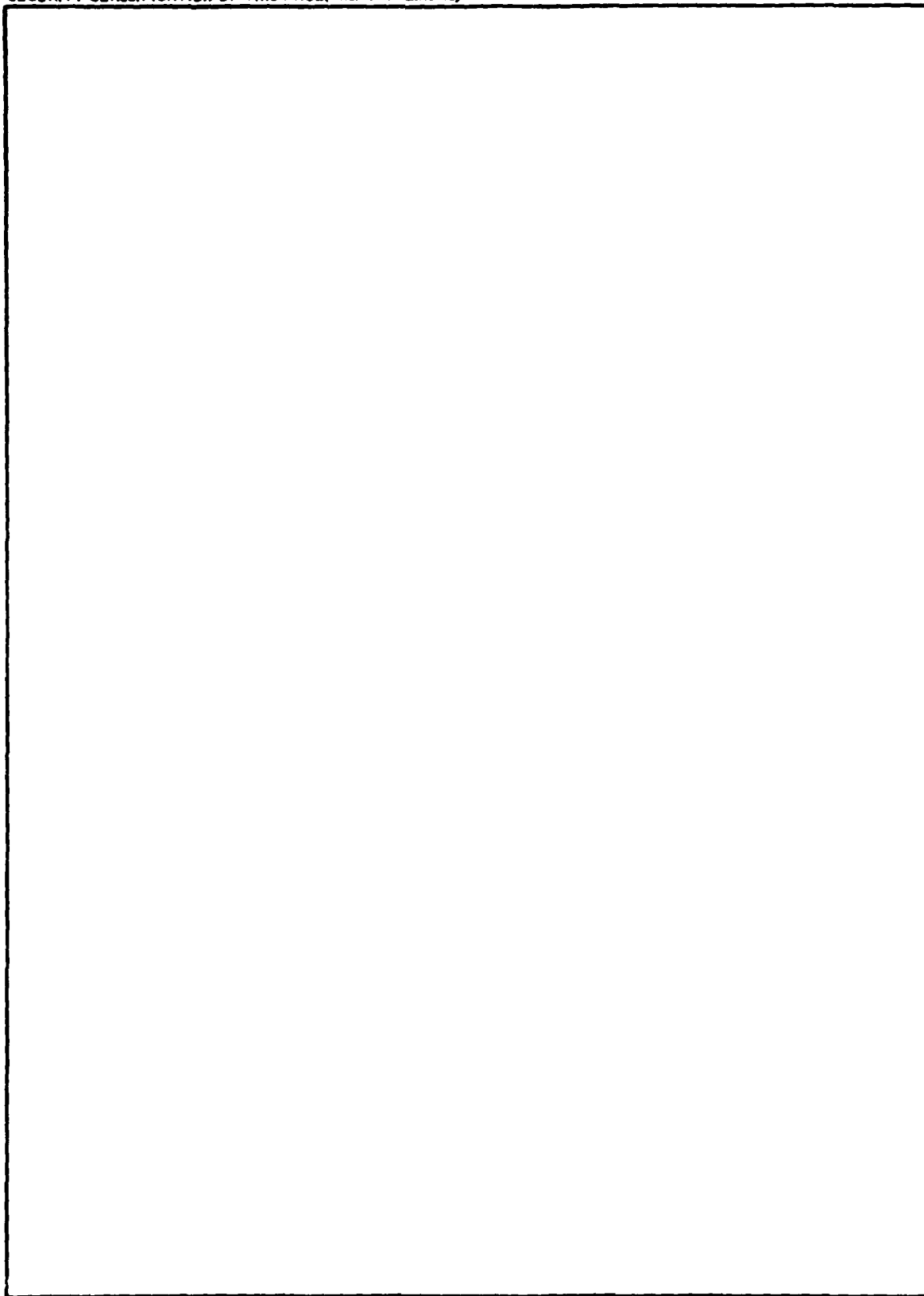
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CONTENTS

	Page
Introduction	1
Background	1
Present Method of Pack	1
Improved Method of Pack (Bulk-Pack System)	1
ARRADCOM Tests	2
Rough Handling Tests	2
Moisture Tests	2
Results of ARRADCOM Tests and Subsequent Improvements	3
Rough Handling Tests	3
Moisture Tests	4
Container Improvements	4
TECOM Tests	4
Results of TECOM Tests	5
User Evaluation	5
Conclusions	6
Appendix: Test Procedure	17
Distribution List	25

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TABLES

	Page
1 Dimensions for cartridge base, chamber gage, and M68 gun breech	7
2 Results of rain test	7
3 Weight and dimensions for present and improved packs	8

FIGURES

1 Present fiber container	9
2 Present wood box (two fiber containers)	10
3 Present unitized pack	11
4 Improved unitized pack	12
5 Present and improved cover tubes	13
6 Damaged components	14
7 Improved cover tube--cross-section view	15

INTRODUCTION

The work described is a result of a product improvement proposal for improved packing and palletization for 105-mm TP-T cartridge M490.

The purpose of this program was to improve logistics and to reduce cost by replacing the old wood packing box for this cartridge with a bulk-pack system and an upgraded fiber container. Any improvements made to the fiber container and the bulk-pack system for the M490 cartridges could be applied to the packing for other tank rounds with little or no modification necessary.

BACKGROUND

Present Method of Pack

The 105-mm M490 cartridges were previously packaged in fiber containers (fig. 1) which consisted of two metal ends, a cover tube, a neck tube (w/neck ring), an outer tube, a nose support, and a spacer tube--all designed around the outer contour of the cartridge. The black outer wrap contained the moisture barrier which consisted of a composite of asphalt-impregnated kraft paper, two layers of aluminum foil, and asphalt duplex-kraft paper.

With the present method of pack, two fiber containers (w/cartridges) were placed into a wood box as shown in figure 2. The wood box was then closed with three steel straps and a metallic seal at the hasp closing.

Twelve or fifteen wood boxes were then unitized in a 3-by-4 or a 3-by-5 array on a skidded base. Four steel straps were used to secure the load. A unitized pack, including 12 wood boxes (with two straps instead of four) is shown in figure 3.

Improved Method of Pack (Bulk-Pack System)

The improved method of pack is shown in figure 4. With this method of pack, 39 fiber containers, nested in a 7-6-7-6-7-6 array, are placed in a pallet-type wirebound box. This box consists of three parts: a top (not shown), a wrap-around side, and a four-way entry pallet base, with the capability of sling application. The box is closed by the wire loops on the pallet side and five steel straps.

Because this pack eliminates the need for the wood ammunition box currently in use, the fiber container must be capable of withstanding the rigors of rough handling now encountered by the wood box.

ARRADCOM TESTS

Rough Handling Tests

Rough handling tests, as prescribed in TECOM Test Operations Procedure 4-2-602, were chosen to evaluate the structural integrity of the fiber containers and their ability to protect the M490 cartridge from the rigors encountered during a rough handling environment. These tests provide a method of evaluating the capability of military items to withstand the rough handling encountered on the battlefield during transport by truck or by the individual soldier. Items subjected to these tests are usually expected to be able to perform satisfactorily; when damaged, however, they must be able to be disposed of safely.

These tests consisted of:

1. A 2.1-meter (7-foot) drop simulating a drop from a truck or a hovering helicopter
2. Loose cargo vibration simulating the transportation of loose cargo by combat vehicle or truck

During the rough handling tests, cartridges, packed in improved fiber containers, were each dropped twice from a height of 2.1 m (7 ft) on a steel surface. Each container was then subjected to a loose cargo vibration test at 5 hertz, 1.3 G, for 30 minutes. Tests were conducted at both -45.6°C (-50°F) and 62.8°C (+145°F).

Moisture Tests

The improved fiber containers were subjected to two moisture tests. One test simulated exposure to a rain environment and one test simulated exposure to a high temperature and high humidity (tropical) environment. These tests were conducted to determine if the covers of the containers could be removed after exposure to extreme climatic conditions. The temperature-humidity test further determined the barrier properties of the container to water vapor.

In the rain test, the containers were subjected, in a horizontal position for 24 hours, to simulated rain amounting to a quantity of 152.4 to 208.2 mm (6 to 8 in.) per hour.

The temperature-humidity test exposed the containers to an environment of 96% RH at 30°C (86°F) for 21 hours and then for 3 hours at 25°C (77°F) for each day in a 28-day period.

RESULTS OF ARRADCOM TESTS AND SUBSEQUENT IMPROVEMENTS

Rough Handling Tests

The approach used to develop an improved fiber container able to withstand the rigors of rough handling was to start with the present fiber container, identify the problem areas that occurred during testing, and correct these deficiencies with the appropriate modifications. Because the present fiber container is packed in a wood box, this container has never been required to pass rough handling tests when outside the wood box.

One problem was that metal ends severed from both ends of the container (crimp failure) after two 2.1 m (7-foot) horizontal or 45° drops. The solution to this problem was to double-crimp the metal ends to the container. The present cover tube has the metal end attached with a single roll-crimp, whereas the improved cover tube has the end attached with an initial press-crimp, followed by the final roll-crimp (fig. 5). The improved (double-crimped) end will resist separation from the container to a greater extent than will the single-crimped end. [By specification Mil-C-2439, the double-crimped end must withstand a force of 6,672 N (1,200 lb) before separating, whereas the single-crimped end must only withstand 3,669 N (800 lb)]

Another problem was the damage to the lip of the cartridge-case base on horizontal or 45° drops. The solutions were to place a metal ring in the cover tube at the point where the lip would impact when dropped, to use PVA adhesive with kraft for the cover tube, to use a mandatory kraft filler in the cover tube, and to increase the wall thickness of the cover tube from 4.32 mm (0.17 in.) to 6.60 mm (0.26 in.).

Damage to the cartridge-case lip as a result of a 2.1 m nose-down 45° drop is shown in A, figure 6. The damage is a flattening of the outer surface of the cartridge-case lip and a bulge to the sides of the lip. This bulging of the cartridge-case lip prevents closing of the chamber-gauge breech. Dimensional requirements of the M490 cartridge and the M68 gun used to fire the cartridges are shown in table 1. A maximum cartridge-case lip of 6.426 mm (0.253 in.) and a chamber gauge clearance of 6.578 mm (0.2590 in.) allows for only a 0.152 mm (0.006 in.) deflection at the lip after impact.

A metal ring with damage that occurred after two 2.1-meter drops on opposite ends of the cartridge is shown in B, figure 6. The ring absorbed the impact force and deformation of the cartridge-case lip was prevented. A cross-section view of the improved cover tube is shown in figure 7.

The 2.75-inch rocket is also packed in a fiber container. Like the 105-mm M490 cartridge, the 2.75-inch rocket is required to withstand a loose cargo vibration test in its fiber container. A problem encountered in loose cargo vibration tests on individual fiber containers for the 2.75-inch rocket was the splitting of the sealing strip [25.4 mm (1 in.) black filament tape MIL-T-43036] between the fibers of the tape. To solve this problem for the 2.75-inch rocket, a 50.8 mm (2 in.) strip of woven cloth tape PPP-T-60, Type IV, was placed over

the sealing strip. Therefore, this solution was also used on the container for the M490.

Moisture Tests

The present vapor barrier works quite well, as evidenced by a maximum moisture gain of 1.7% in the 28-day temperature-humidity test. The only problem encountered in the moisture tests was the problem of cover tube removal after exposure to the rain test (table 2). The problem was caused because the black filament tape did not provide an adequate water seal. This problem was solved by the addition of the 50.8 mm woven cloth tape also used for the 2.75-inch rocket container.

Container Improvements

As a result of the ARRADCOM tests, the following improvements were officially adopted for the fiber container:

1. Metal ends double-cripped to container
2. Metal ring added in cover tube
3. PVA adhesive used with kraft paper for cover tubes
4. Kraft filler in cover tubes made mandatory
5. Outer tube wall thickness increased from 4.32 mm (0.17 in.) to 6.60 mm (0.26 in.)
6. Spiral kraft or convolute chipboard nose support substituted for plastic nose support
7. Woven cloth tape applied over old sealing strip
8. Clearance increased to 0.762 mm (0.03 in.) between cover tube and neck tube, and cover tube lengthened

TECOM TESTS

The improved packaging was sent to TECOM at the Aberdeen Proving Ground and Yuma Proving Ground for a rigorous performance test of the fiber container and the full pallet. Tests were performed on both individual containers and palletized configurations, and firing tests were run. The objectives of these tests were two-fold:

1. To determine the satisfactoriness of the improved packing and palletization methods

2. To provide a ballistic comparison between those rounds tested in the standard pack and those in the improved pack

The major tests conducted by TECOM included:

1. 12.2-meter (40 foot) drop test
2. Air drop capability test [conducted at Yuma Proving Ground (YPG)]
3. Secured cargo vibration test
4. Rough handling tests (2.1-meter drop test and loose cargo vibration test)

The test program, including order of tests and volume tested in each, and the ballistic test procedures, are outlined in the appendix.

RESULTS OF TECOM TESTS

In all tests conducted, the improved packing and palletization technique protected the cartridges as well as the present packing. The cartridges subjected to these tests in both the present and the improved pack were compared ballistically for average muzzle velocity, maximum velocity, and target dispersion.

According to the TECOM ballistic report, analysis of the raw data indicated that velocity and target dispersion levels of test and present ammunition were comparable and that no safety problems were observed with the improved method of pack.

The results of the air drop tests conducted at YPG show that all cartridges can be easily removed from the containers in an undamaged condition after being dropped at high velocity from an aircraft. Ballistic tests on these cartridges also indicate no adverse effects to the cartridges.

USER EVALUATION

A packed pallet-type wirebound box was sent to the U.S. Army Armor Center, Fort Knox, Kentucky for user evaluation. Here the packing was analyzed from the standpoint of the soldiers in the field. Considered factors were manageability and handling, ease of access to the cartridges, and general performance of the packaging in an action situation. Information regarding weight and dimensions for the present and the improved pack is shown in table 3.

Results from Fort Knox showed that the proposed packing concept is a significant improvement over the current method of pack as it pertains to handling of 105-mm ammunition in a training environment.

As a result of this study, the method of pack for the 105-mm TP-T cartridge M490 was officially changed from the standard wood box pack to the bulk pack system with the improved fiber container, therefore allowing the improved method of pack to be used in the future.

CONCLUSIONS

The following conclusions were made:

1. The improved method of pack for the 105-mm TP-T cartridge M490 provides protection equal to or greater than that provided by the present wood box pack and at a reduced cost.

2. The improved method of pack provides easier access to ammunition as a result of the elimination of the wooden boxes and their strapping.

3. The improved method of pack reduced the weight of the as-packed cartridge by 14%, which represents a 59% reduction in the packaging material weight.

4. The improved method of pack is easier to handle. (The container is now the unit pack; it can be handled by one person as opposed to two persons for the present wood box.)

5. The improved method of pack satisfies the requirements of a Rapid Deployment Task Force since the new fiber container represents a lightweight, one-step-access pack.

Table 1. Dimensions for cartridge base, chamber gage, and M68 gun breech

<u>Item</u>	<u>Dimension</u>			
	<u>Minimum</u>		<u>Maximum</u>	
	<u>mm</u>	<u>in.</u>	<u>mm</u>	<u>in.</u>
Cartridge M490	6.172	0.243	6.426	0.253
Chamber gage	6.579	0.2590	6.579	0.2590
M68 gun breech	6.655	0.262	7.163	0.282

Table 2. Results of rain test

<u>Conditions of container</u>	<u>Containers tested</u>	<u>Containers with covers able to be removed after rain test</u>
Without tape	6	0
With 25.4 mm (1 in.) black filament tape	6	3
With 25.4 mm (1 in.) black filament tape plus 50.8 mm (2 in.) green woven cloth tape	6	6

Table 3. Weight and dimensions for present and improved packs*

Pack	Unitized pack weight		Unitized pack volume		Weight per cartridge		Volume per cartridge	
	kg	lb	m	ft ³	kg	lb	m ³	ft ³
Present--30 cartridges	970.23	2,139	1.567	55.3	32.34	71.3	0.052	1.84
Present--24 cartridges	790.61	1,743	1.306	46.1	32.93	72.6	0.054	1.92
Improved (39 cartridges)	1,103.14	2,432	1.328	46.9	28.30	62.4	0.034	1.20

* % reduction per cartridge in weight and volume:

	Weight	Volume
30 vs 39 cartridges per unitized pack	12.5	34.8
24 vs 39 cartridges per unitized pack	14.1	37.5



A - Cross-section view



B - Exterior view

Figure 1. Present fiber container

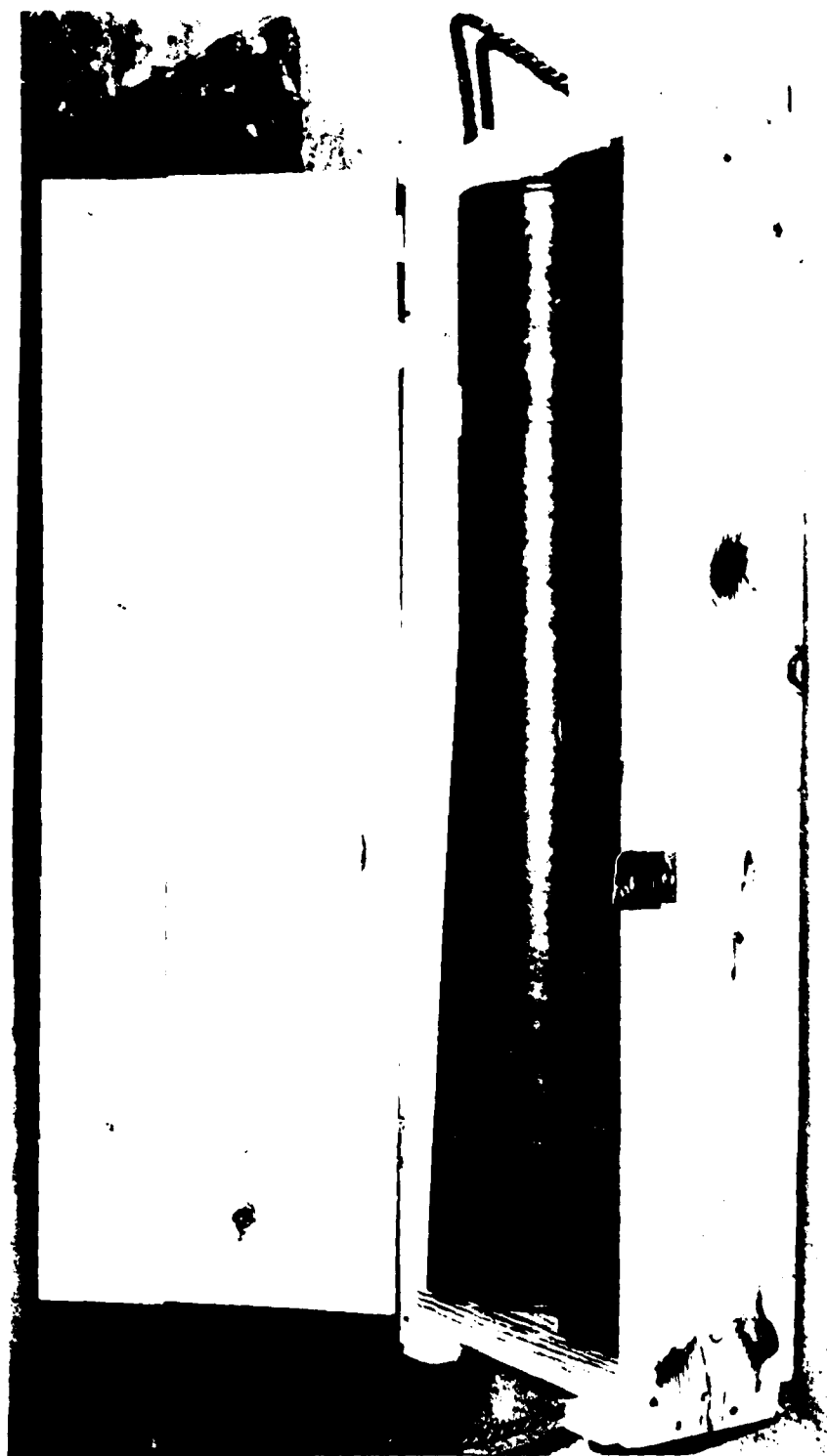


Figure 2. Present wood box (two fiber containers)

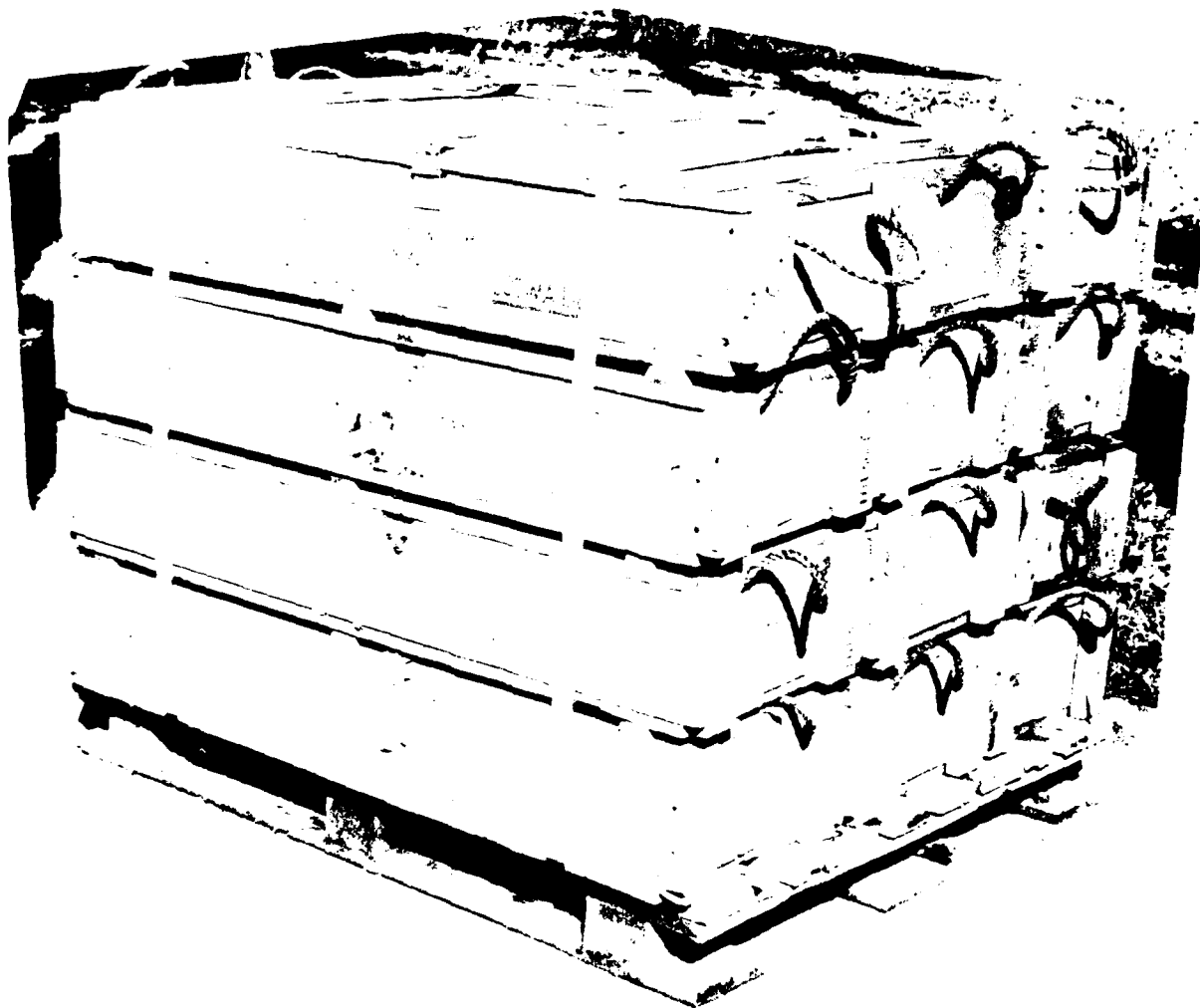


Figure 3. Present unitized pack

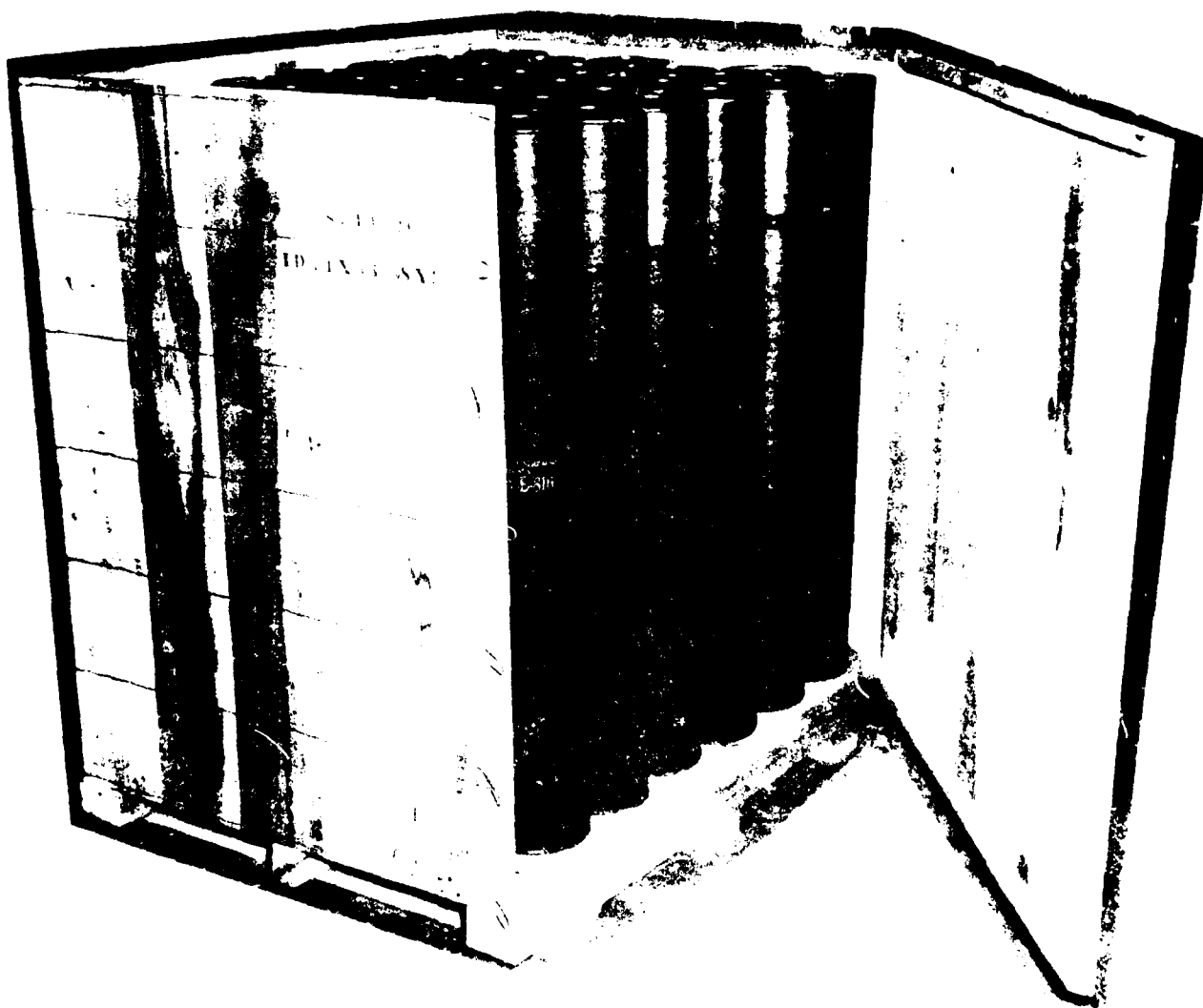


Figure 4. Improved unitized pack

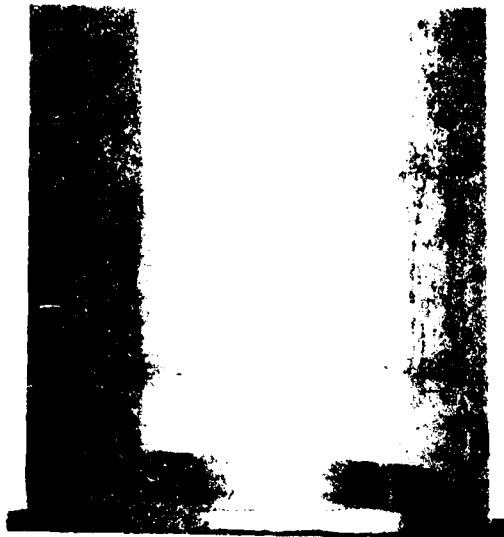


A - Present cover tube



B - Improved cover tube

Figure 5. Present and improved cover tubes



A - Cartridge-case lip



B - Metal ring from cover tube

Figure 6. Damaged components



Figure 7. Improved cover tube--cross-section view

APPENDIX
TEST PROCEDURE

Test Program:

a. Pack and palletize all cartridges in accordance with the following drawings:

1. Standard method - Unit packaging (fiber container) - Dwg 8837832
Overpack (wood box) - Dwg 8837831
Palletization (wood pallet) - Dwg 19 48 4020 1-2-5-11-PA-1001
2. Improved method - Unit packaging (fiber container) - Dwg 9328579
Palletization (pallet box) - Dwg 9328580

b. Order of Performance of Major Tests:

1. Forty (40) foot drop (TOP 4-2-601)
2. Air drop capability (TOP 4-2-509)
3. Secured cargo vibration (1-2-601)
4. Seven (7) foot drop (TOP 4-2-602)
5. Loose cargo vibration (TOP 4-2-602)

c. Forty (40) Foot Drop Test (TOP 4-2-601)

1. Two (2) pallets each of both the standard method and the improved method will be subjected to this test.

2. For this test the round need not be operable but shall not burn or detonate and shall be safe to handle for disposal.

d. Airdrop Capability Test (TOP 4-2-509)

1. Two (2) pallets each of both the standard method and the improved method will be subjected to this test.

2. The suitability of both the standard and the improved packing method will be determined by an evaluation of these test results.

3. Following these tests, additional comparative data will be collected by performing firing tests for:

- (a) Average muzzle velocity
- (b) Maximum velocity
- (c) Dispersion

e. Secured Cargo Vibration (TOP 1-2-601):

1. Two (2) pallets each of both the standard method and the improved method will be subjected to this test.

2. This test will be run at both +145°F (62.78°C) and at -50°F (-45.56°C).

3. Vibration cycling to be in accordance with figure 1 of the applicable TOP and those changes detailed in letter AMSTE-ME, dated 20 July 1975, subject: Transportation Vibration (T-V) Testing, paragraph 4.b.

4. Following these tests, additional comparative data will be collected by performing firing tests for:

- (a) Average muzzle velocity
- (b) Maximum velocity
- (c) Dispersion

f. Seven (7) Foot Drop Test and Loose Cargo Vibration (TOP) 4-2-602:

1. Forty (40) cartridges packaged in fiber containers of both the standard method (box overpack) and the improved method will be subjected to this test.

2. This test will be run at both -50°F (-45.56°C) and +145°F (62.78°C).

3. The standard packing method will be conducted in accordance with the following chart and notes.

Notes:

a. Impact Surface - 3 inch (7.6 cm) steel plate supported by at least 18 inches of crushed rock.

b. Drop Orientation Code

- A - Bottom
- B - Right End
- C - Left End
- D - Bottom Right End Edge
- E - Bottom Left End Edge

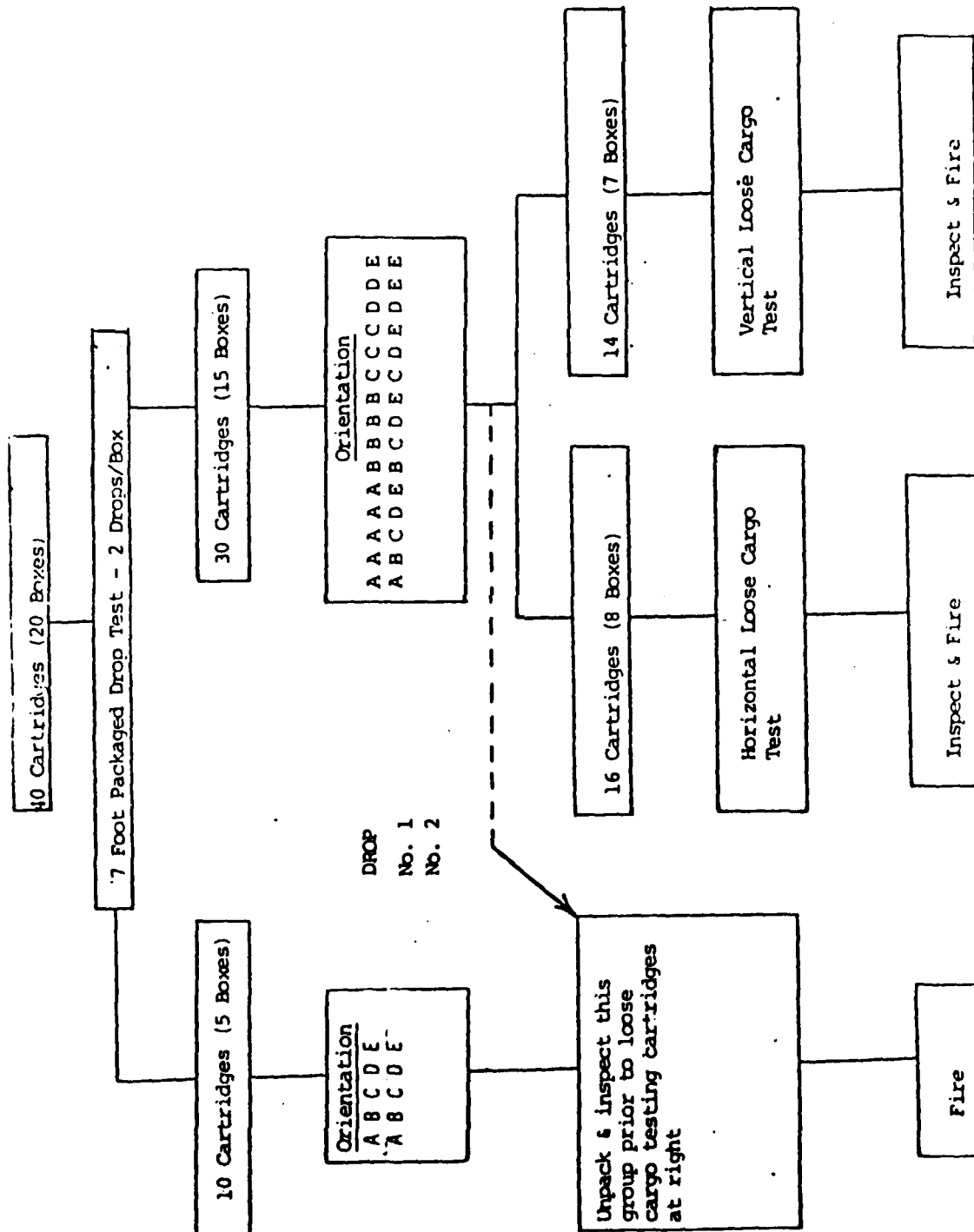
c. Firing tests will be to arrive at the following minimum information:

- Average muzzle velocity
- Maximum velocity
- Dispersion

4. The improved packing method will be conducted in accordance with the following chart and notes:

Notes:

a. Impact Surface - 3 inch (7.62 cm) steel plate supported by at least 18 inches of crushed rock.



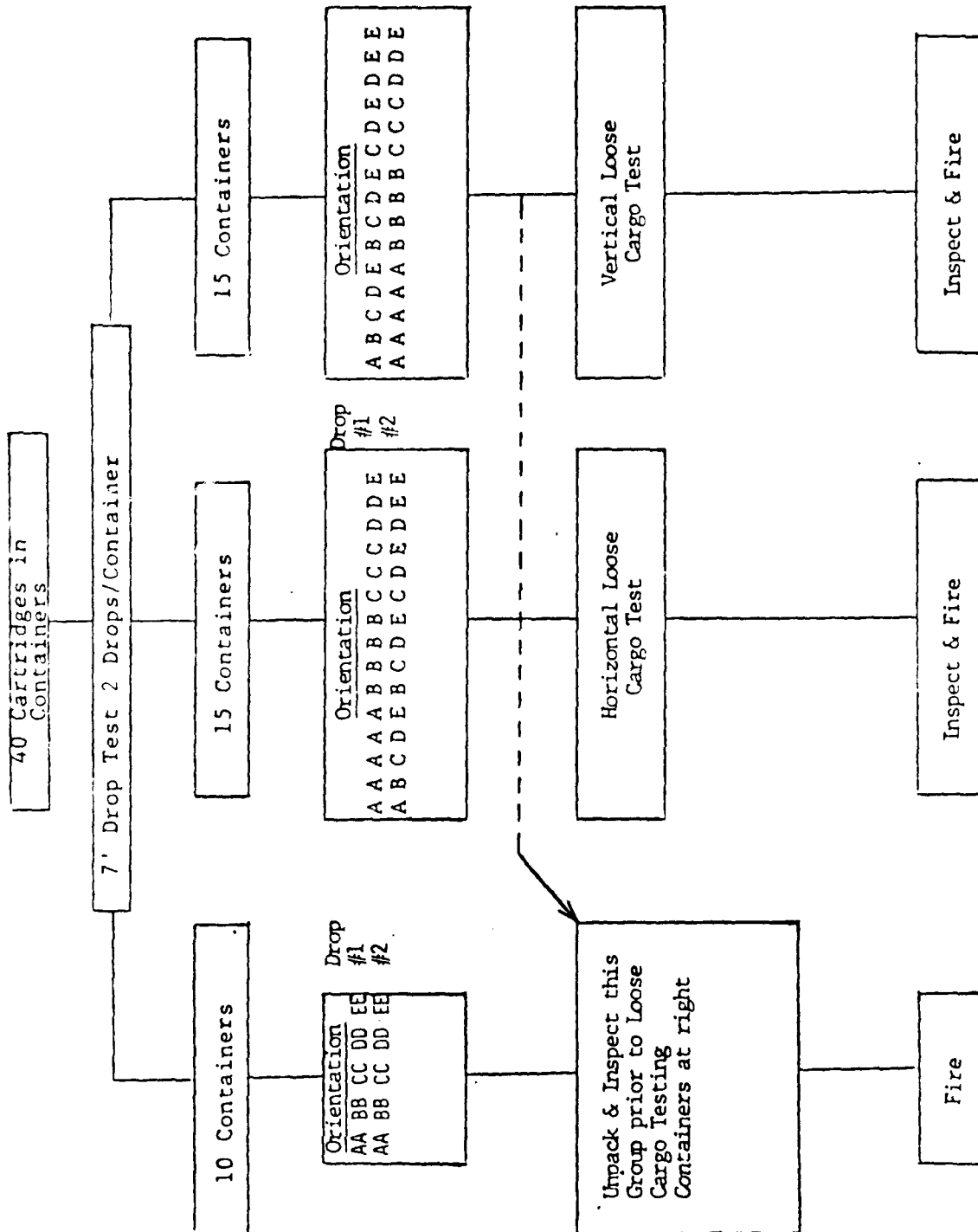
STANDARD PACKING ROUGH HANDLING PROCEDURE

b. Drop Orientation Code

A - Horizontal
R - Base down
C - Nose down
D - Base at 45°
E - Nose at 45°

c. Firing tests will be to arrive at the following minimum information:

Average muzzle velocity
Maximum velocity
Dispersion



EXPROVD PACKING ROUGH HANDLING PROCEDURE

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